# Microphysical Insights from GPM DPR Observations of Mesoscale Convective Systems

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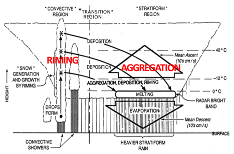
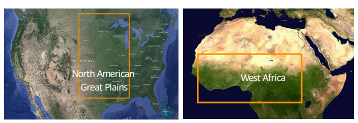
## Mesoscale Convective System (MCS)




Two MCS-frequent area (orange boxes) chosen for the current study




Schematic MCS cross section with a trailing stratiform region, copied from Houze (1989, QJRMS).

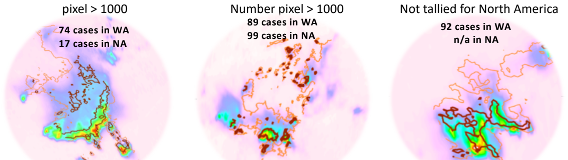
Mesoscale Convective Systems (MCSs) are organized precipitation systems with convection clusters and extensive stratiform regions. They have relatively long lifespans with quasi-steady mature stages that last from several hours to days. As shown in the schematic, the convective and stratiform region in mature MCSs have different dynamics and dominant microphysical processes. Our goal is to find common statistics observed by the GPM satellite, and to use them to understand cloud microphysical processes (e.g., aggregation of ice-phase particles), and to validate microphysical schemes in the Weather Research and Forecasting (WRF) model. MCS samples are identified from two MCS-frequent areas (orange rectangles above). The MCS system initiation mechanisms are similar at these two locations. The mountain ranges interact with mean flow and trigger convection downwind. The convection propagates with the mean flows, and are often organized into MCSs by vertical wind shears. The GPM Precipitation Feature database with collocated level 2 data during the summer months between May 1 and September 1, 2014~2017, are sampled.

## Stratiform Ku-band CFADs

**Squall Line**
Linear leading convective region with extensive trailing stratiform region; Along line length > cross line width in 89 GHz PCT. Number pixel > 1000

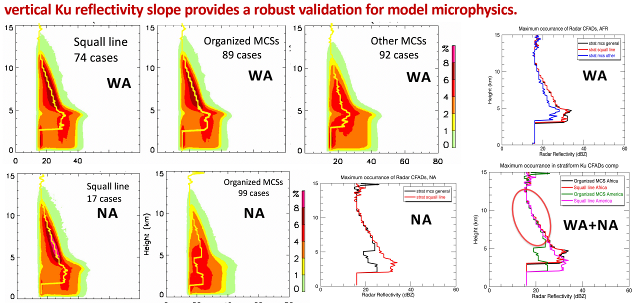
**Organized MCS**
Generally shows clustered convective region and trailing stratiform region, but not well-defined; length < width; Number pixel > 1000

**Other MCS**
Has both convective and stratiform regions, but convection are embedded and scattered; Number pixel > 1000
Not tallied for North America



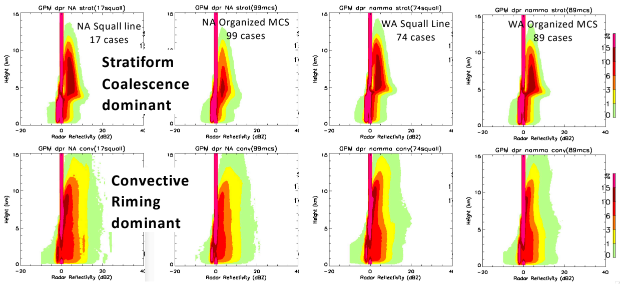

Images are GMI 89 GHz PCT, with dark red and orange lines representing Ku band 40 and 20 dBZ contours

Vertical profiles of Ku-band reflectivity Contour Frequency by Altitude Diagrams (CFADs) in the stratiform region show remarkable agreements between **squall lines** and **organized MCSs above 5km altitude**, in locations. This indicates common microphysical process(es), most likely aggregation, are shaping ice-phase particle sizes in the trailing stratiform region. **Consistency in vertical Ku reflectivity slope provides a robust validation for model microphysics.**

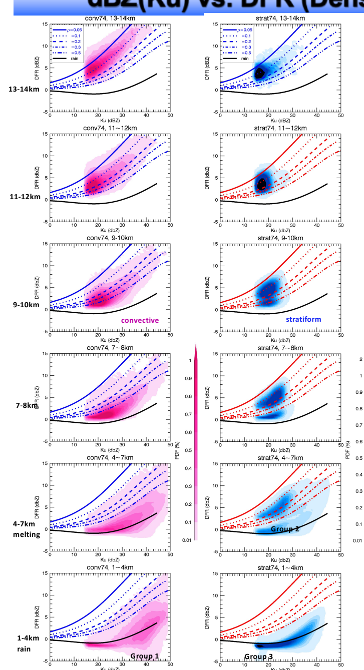


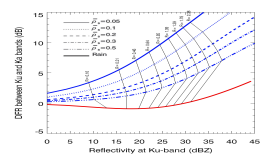

## DFR CFADs (convective vs. stratiform)

Dual-Frequency Ratio (DFR=dBZ(ku)-dBZ(ka)) CFADs show different characteristics. In the stratiform region (upper row), DFR increases with decreasing heights above the melting level, resulting from increases of mean ice-phase particle sizes due to **coalescence**. In the convective region (lower row), DFR decreases, because increasing particle densities outweigh increasing particle sizes due to the dominant role of **riming** in strong convection.




## dBZ(Ku) vs. DFR (Density Variations)

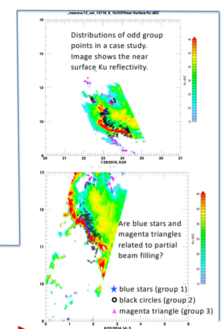


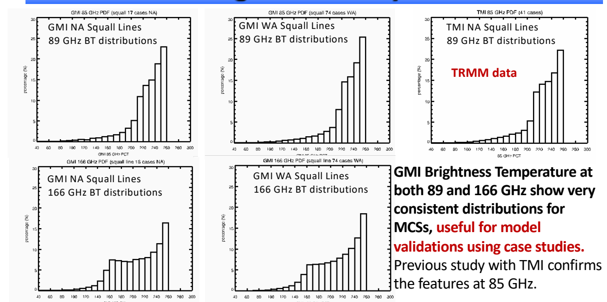

Theoretic calculation of various ice-phase particles' bulk density using exponential particle size distributions. *Copied from Liao and Meneghini* (2011)

dBZ (Ku) vs. DFR probability density plots for the 74 squall line cases in West Africa clearly show contrasting ice-phase particle density variations with heights for the convective (magenta) and stratiform (blue) regions. In the convective region, data distributions show increases of bulk density with decreasing heights, from ~0.1 $g/cm^3$ at 14km to >0.5 $g/cm^3$ at 7km. This is consistent with the DFR CFADs vertical trends shown in the previous section. **It indicates the dominance of the riming process in growing ice-phase particles in the convective region**. On the other hand, the stratiform data mostly cluster in two distinct groups, one with low-density of between 0.1 and 0.2 $g/cm^3$ at all heights. **This is the true stratiform signal where ice-phase particles grow by coalescence, therefore have small changes in their bulk density**.

The other group (group 2 labeled in plots) behaves more like convective data with increasing density. This group most likely belongs to the transition zone immediately next to the convection, as shown by two cases illustrated to the right.



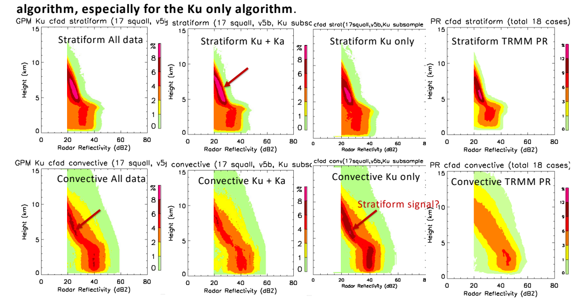

## GMI Brightness Temperature



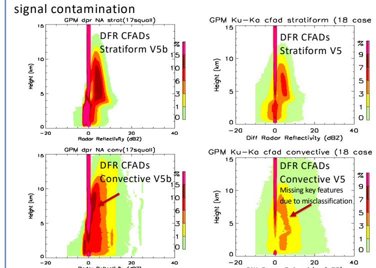

**GMI Brightness Temperature at both 89 and 166 GHz show very consistent distributions for MCSs, useful for model validations using case studies.** Previous study with TMI confirms the features at 85 GHz.

## Convective/Stratiform Separation

GPM convective/stratiform separation algorithms are of paramount importance for the current study, revealing contrasting microphysical characteristics and distinct microphysical processes from case samples. The MCS cases have well-defined convective/stratiform regions and can be used to test the c/s algorithms. **There are indications of misclassifying stratiform as convective in V5b algorithm, especially for the Ku only algorithm.**




Earlier V5 c/s separation algorithm missed the DFR variation characteristics in the convective region due to stratiform signal contamination




Suggestions/comments are highly appreciated: xiaowen.li@nasa.gov Thank you!